

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of)
)
Amendment of Parts 1, 2, 22, 24, 27, 90 and 95 of) WT Docket No. 10-4
The Commission's Rules to Improve Wireless)
Coverage Through the use of Signal Boosters)
)

EX-PARTE COMMENTS AT THE REQUEST OF STAFF

August 13, 2012

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I. COMPANY BACKGROUND

Tri-Power Group is a privately-held technical services company headquartered in Livermore, CA.

TriPower is one of west coast's largest and one of the most experienced systems integrators providing in-building public safety and cellular coverage throughout the United States. TriPower has earned the reputation of delivering high quality public safety grade DAS systems in hospitals, jails, police facilities, casinos, condominiums, apartments and other enterprise projects.

Since 2000, Tri-Power Group has been assisting wireless carriers, public safety officials, building owners, corporate enterprises, and other constituents to create systems that provide seamless and robust wireless coverage. Some of Tri-Power Groups credentials include:

- More than 1200 wireless DAS implementations
- Over 1800 wireless system designs and propagation analysis'
- Current installations provide over 300 million square feet of wireless coverage
- Currently, approximately 85% of all TriPower DAS implementations either support a public safety entity, or were driven by a public safety ordinance.

TriPower reference projects

- City of Los Angeles; Metro Detention Center (470 -512 MHz)
- County of Riverside; Smith Correctional Facility (700/800 MHz)
- State of Utah; Utah State Capitol Building (800 -2.5 Gig)
- City of Mesa; Mesa Art Center, Mesa Arizona (UHF – 2.5 Gig)
- Phoenix Children’s Hospital, Phoenix Arizona (UHF – 2.5 Gig)
- Kaiser Hospitals throughout Northern California (VHF – 2.5 Gig)
- Kemper Development Company; Bellevue Washington (800 – 2.5 Gig)
- Moffett Towers; City of Sunnyvale CA public safety system (UHF)
- Stanford Linear Accelerator Tunnels, Stanford CA (VHF)
- Mills Peninsula Hospital, San Francisco CA (VHF – 2.5 Gig)
- Amazon Corporate Center, Seattle Washington (800 – 2.5 Gig)
- Sacramento International Airport, Sacramento CA (UHF – 2.5 Gig)
- John Muir Health, Walnut Creek and Concord CA (UHF – 2.5 Gig)
- Parkview Medical Complex, Fort Wayne IN. (VHF – 2.5 Gig)

TriPower has designed and delivered systems using the following manufacture's equipment;

- Mobile Access (Fiber DAS)
- Solid Technologies (Public Safety Grade fiber DAS)
- LGC Wireless (Fiber DAS)
- Andrew (Indoor/Outdoor Fiber DAS)
- PowerWave (Fiber DAS)
- ADRF (BDA)
- Rtron (BDA)
- CSI (BDA)
- TX/RX (Public Safety Grade BDA)
- Dekolink (BDA)

TriPower's three member Executive Engineering staff has a combined 63 years of Military and Public Safety Communications design experience. Gregory Glenn, Director of RF Engineering also works closely with public safety grade BDA and DAS vendors here in the United States and abroad. Mr. Glenn conducts seminars nationwide for APCO and others who wish to understand DAS systems from a very basic level through component and engineering level. Glenn has been published on this this subject.

II. Executive Summary

We thank the Commission for reading prior comments and for the effort being set forth to analyze the current situations as it pertains to Signal Booster (BDA) and DAS deployments. At the behest of Staff TriPower Group is submitting the following ex parte comments on specific subjects outlined by the Commission.

With respect to Part 90 Private Land Mobile signal boosters, the commission seeks to revise technical and operational requirements for these devices, but it should be understood that much of the BDA interference caused to the public safety Part 90 users is in fact created by amplifiers designed to operate in the Part 22 cellular portion of the 800 band as well as the Part 90 portions of the 800 MHz band.

TriPower would ask the Commission to keep in mind that in many circumstances both part 90 and part 22 systems are being deployed in the same building so it is important to look at the interactions of both services most particularly at the band edges.

TriPower will, to the extent possible, provide as much technical information, to support their conclusions.

III. Comments

- 1.) **Should the Commission limit the power output of a Class A on B BDA to 5 watts ERP, and should this limitation be based on composite output (all carriers within the L/C pass-band combined) or should the 5 watt limit be assessed on a per channel basis? (I.E. each channel within the L/C pass-band will be limited to 5 watts ERP)**

TriPower does **not believe** that a **5 watt limit is necessary** under part 90 as long as these amplifiers can maintain spectral purity and not create noise in adjacent bands. However, if the Commission elects to keep or redefine this rule we would recommend the following.

Our engineering staff defines ERP as true RF power – splitter/cable loss + antenna gain. It should be noted that unless a booster were equipped with a line kit and antenna, the booster itself would not have a defined ERP limit. Thus the ERP limit would become the responsibility of the installing integrator and/or licensee. It is our opinion that BDAs, Signal Boosters and DAS Amplifiers would have to be rated at true RF power output.

TriPower has no issue with a 5 watt per channel rating provided that the amplifier can control power output on a per channel (per pass-band) basis. This will probably require the use of a DSP, narrow L/C or SAW filters and individual power controls. With today's technology, and in actual practice any BDA, signal booster or DAS amplifier running DSP will probably be passing a bandwidth greater than one channel in order to reduce time domain interference problems. Under this circumstance it would be

possible for two or more channels to pass through a single DSP pass band. The same would hold true if an amplifier were to use multiple L/C or SAW filters to accomplish multiple band pass windows. It would make sense that the amplifier be rated based on the **composite power** within the **pass band** of that particular DSP or L/C filter set.

With regards to band pass amplifiers not incorporating DSP or using a single LC or SAW window, a 5 watt composite power level would need to be implemented to prevent the possibility of a single channel exceeding the 5 watt output limit.

2.) Should the Commission eliminate the use of 18 MHz wide pass band amplifiers within the Part 90 - 800 MHz portion of the RF spectrum or should amplifiers be designed to pass only a given service.

For the purpose of this discussion TriPower will refer to the Part 90 - 800 MHz band as supporting three distinct services.

- a.) Public Safety 851-855 MHz (post re-band)
- b.) interleave channels 855-860 MHz (LMR, Public Safety, other services)
- c.) ESMR 861 MHz and above

In reference to Public Safety (a) and interleave channels (b) above;

TriPower supports the notion that it is not good practice to pass spectrum that is unnecessary, and in practice we specify amplifiers with multiple pass windows to accommodate such. We believe that the spectrum pass-bands should be defined by the engineer designing the system. In a large venue situation it is very often necessary to pass different channels from different services within the 800 MHz Part 90 spectrum. While the use of multiple amplifiers **may** be a good solution, considerations such as filter cross over and phasing must be taken into account when doing such. Often times it is possible and preferable to use a single amplifier with multiple pass band windows to source signals from multiple services.

Furthermore it is very common within the public safety arena to see a public safety entity operating frequencies from the (post re-banding) NPSPAC portion of the band (851 – 855 MHz) as well as the interleave portion of (855 – 860 MHz) the Part 90 - 800 MHz band.

In this case we do not believe the Commission should take any action to **require** that separate amps be used to pass various services within the 851 – 860 MHz portion of the band.

In reference to ESMR (c) - upper portion of the 800 MHz band;

From an operational standpoint, there can be a clean break between ESMR and PS/LMR portion of the 800 MHz band. In the case of the ESMR amplifier, TriPower has no issue if the Commission elects to require the amplifier cut off below 861/816 MHz.

It should be noted that in both cases amplifiers should use L/C filtering on the output of both the uplink and downlink power stages so as not to cause unnecessary interference and noise to their adjacent services.

3.) Should the Commission define a maximum noise figure for Part 90 – 800 MHz signal boosters?

Tri-Power does not believe it is necessary for the Commission to define a maximum noise figure for any signal booster, BDA or DAS. However TriPower believes that a **maximum noise figure specification should be published**. It appears to be common practice (especially on carrier amplifiers) to apply attenuation at the input of fixed gain amplifiers to reduce the overall system gain or to reduce the potential for RF overload. While this may be effective, it increases the overall noise figure of the amplification system. On poorly filtered amplifiers can lead to interference problems in adjacent bands.

4.) Should the Commission define a pass-band filter response as it pertains to the edges of the L/C filter pass-band?

TriPower is in favor of the Commission defining the maximum level of out of band noise that will be accepted from a signal booster, BDA or DAS amplifier. Many talk of filter roll off at the edge of the pass band as being the specification that should be used. Some will specify a 55 dB roll off at 1 MHz and some 30 dB roll off at 1 MHz outside of the pass band. Unfortunately, this has become a marketing tool used to specify a certain amplifiers. Below you will find two sweeps of generally available filter sets used in part 90 amplifiers. These filters serve to protect the cellular operator's spectrum below the operational band of these amplifiers. Both of these filter sets are from FCC Type accepted amplifiers.

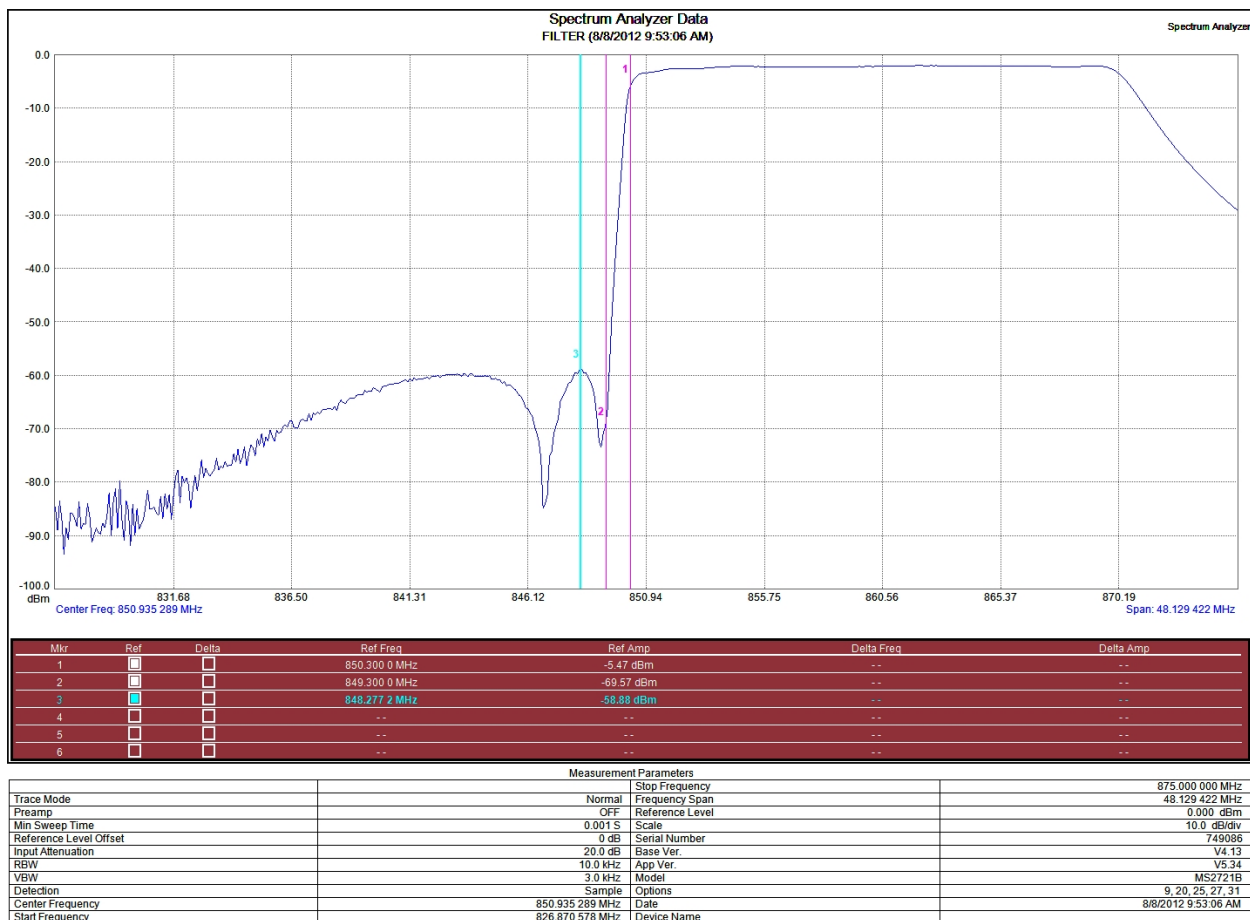


Figure 1

Figure 1 (above) shows the response of a well-designed L/C filter used on the output of a **Part 90** BDA.

This filter is used to protect the part 22 operator from potential noise and intermodulation products that may be produced by this amplifier. 850.3 MHz is the filters 3 dB down point or half power point. At 1 MHz away 849.3 MHz filter rejection is at 69 dB. At 848.277 MHz filter rejection drops to 58 dB.

Insertion loss on this filter is about 2.6 dB. Assuming that broad band noise or intermodulation products hit this filter at -11 dBm below 849.5 MHz (-13 + 2 dB for insertion loss of the filter). Any noise product that passes through this filter below 849.5 would be rejected by at least 59 dB. Thus the -11 dBm intermodulation product would leave the filter at -70 dBm. Taking this one step further, let's assume this noise was being radiated from one indoor antenna supporting Part 90 service (A1) and

being coupled into an antenna supporting Part 22 services at a 20 feet separation (A2). The resultant interfering signal at antenna A2 would be 16 dB above kTB. (-118 dBm 10 KHz RBW)

That being said it is common for the output of a signal booster or DAS amplifier to be split to multiple antennae and with cable loss this would probably be a workable solution. Note that rejection at the high end of the band does need to be addressed; however this would impact other downlink signals.

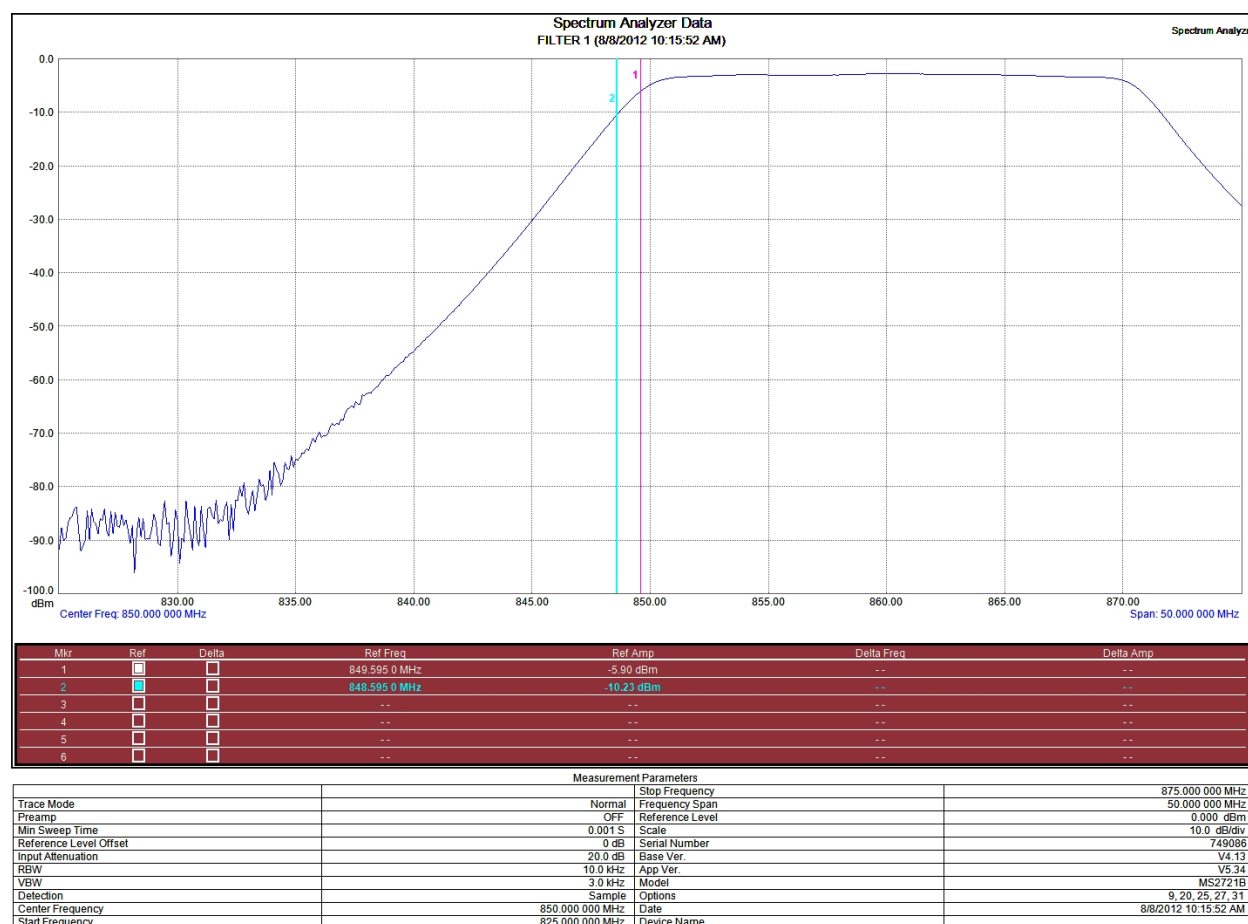


Figure 2

Figure 2 (above) shows the output filter response of another filter set used by another **Part 90** BDA. This filter is used to protect the part 22 operator from potential noise and intermodulation products that may be produced by this amplifier. Note the roll off of this filter. 10 dB at 848.5 MHz! Without going through a large math exercise this filter is 48 dB worse than the filter used in Figure 1. To put this in perspective, assuming the Part 90 signal booster in figure 1 would stand next to a Part 22 DAS system in the same building with 20 foot antenna spacing, the signal booster depicted in figure 2 would require an antenna separation of over 1000 foot to maintain the same interference level . Not likely to be an option for an in building application. Unfortunately the filter set depicted in figure 2 is the more common scenario.

A few notes on the thermal noise levels;

Both of these amplifiers have a maximum gain of 80 dB. Assuming that no intermodulation products were being produced by these amplifiers while in operation (highly unlikely) the thermal hash due to amplifying the kTB noise would be in the neighborhood -50 dBm (as measured at 10 KHz RBW). The amplifier depicted in Figure 1 from above, would create no noticeable noise rise to a cellular DAS or signal booster with antennas 20 feet away at 848.5 MHz. The amplifier depicted in Figure 2 would create a noise rise at the cellular DAS of 26 dB with antennas separated by 20 feet.

While it may not be necessary to use high quality filters on a consumer based amplifier we believe that the Commission should set standards as to hum, noise and spurious emissions as it pertains to part 22 amplifiers generating noise into the part 90 portion of the band as well as part 90 amplifiers generating noise into the part 22 portion of the 800 MHz band. TriPower believes that rather than specifying filter

response curves the Commission should adopt an **out of band power level** that **shall not be exceeded**.

This allows manufacturers and integrators the flexibility to use whatever means necessary to meet these standards. (DSP, mechanical, or ceramic filter etc.)

TriPower would suggest that the ERP generated by any amplifier 1 MHz off of its designed service band be no greater than **-75 dBm ERP** (as read using a spectrum analyzer or power meter with a 10 KHz resolution bandwidth + antenna gain) for both noise and intermodulation products. This rule should be adopted for all amplification systems, BDA or DAS component. Under this rule math calculations indicate that on the downlink or forward link side that any thermal noise or intermodulation products generated by a **part 22-850 MHz** cellular amplifier within the **part 90 portion of the 800 MHz** band (noise below 868 MHz) will produce a signal no greater than -115 dBm on any given floor at 10 foot off of the service antenna. This will prevent the addition of **Part 22** cellular amplification systems from raising the noise floor within a building to a point where a **-95 dBm** signal level from the **Part 90 public safety** system is no longer effective to carry out public safety communications within said building. This also protects the public safety base station receive sites from noise rise due to thermal noise/intermodulation generation on the uplink/reverse link side. **A -75 dBm ERP** noise level leaving the donor antenna on the uplink side would only generate noise for about 100 feet assuming no antenna gain. If one were to assume normal antenna gains say 10 dB on the donor Yagi and 8 dB on base station receive antenna a 6 dB noise rise would only occur up to 320 foot out from front of donor antenna.

TriPower would suggest that the same specifications be used for **Part 90** amplifiers as they cross into **Part 22** territory.

If the Commission elects to break up the **Part 90** band into commercial/public safety/LMR than the same rule -75 dBm ERP rule should apply.

A mobile consumer grade amplifier (**Part 22 or 90 or 95**) should be able to meet these goals as they will have relatively low gain and low power output.

5.) Should the Commission define the maximum spurious emission levels that can be produced by a part 90 signal booster?

While TriPower would like to think that the industry would use properly engineered and designed products across the board it seems to be that price has become such a driving factor that maintaining spectral purity is an afterthought. Please observe the uplink output sweep in figure 3. This is an FCC type accepted part 90 amplifier.

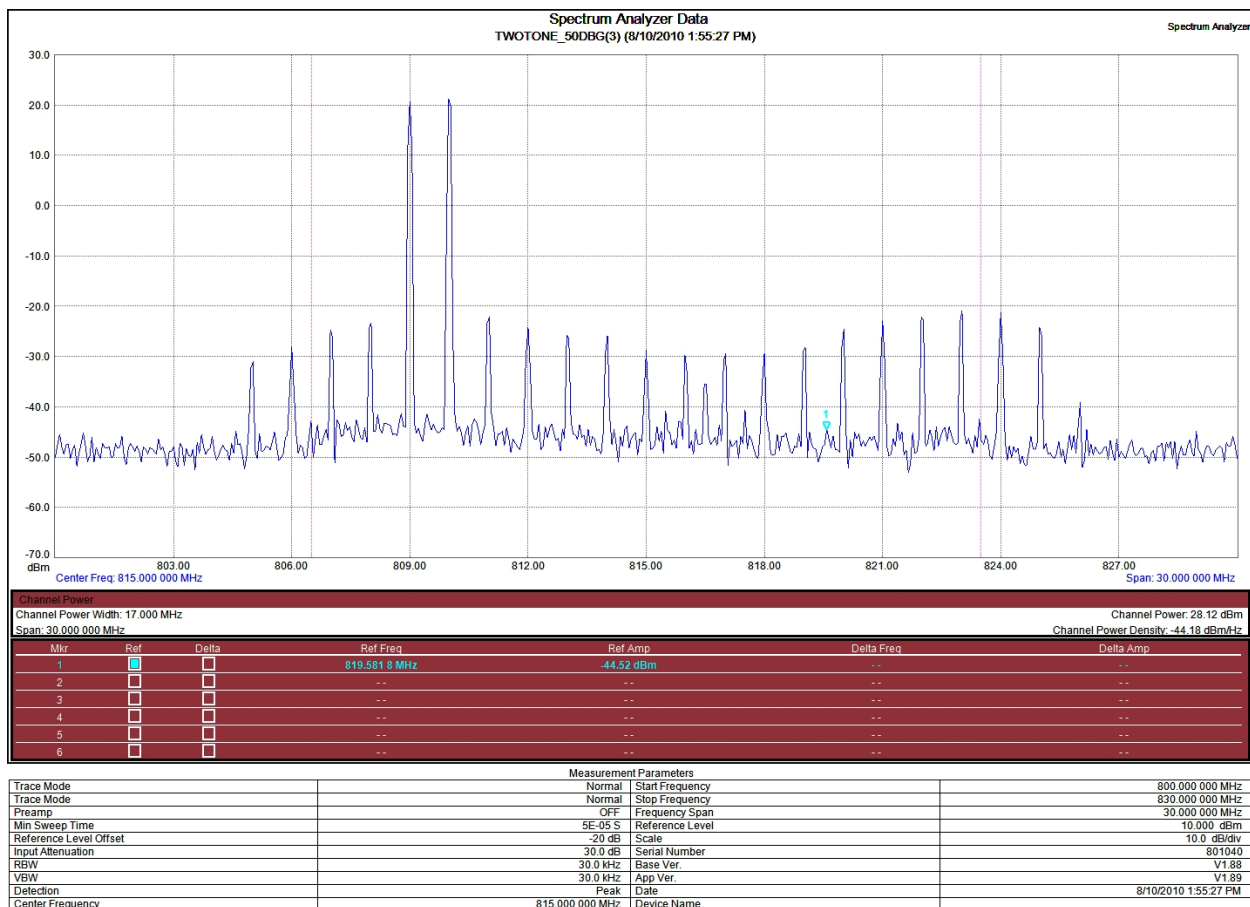


Figure 3

Figure 3 is a two tone test sweep that was performed in the TriPower lab. Please note the spurious emission or RF regeneration created by this amplifier. While the Commission does not have a hard specification on noise and intermodulation, we at TriPower believe that the Commission needs to set specification on IMD levels.

While most manufacturers that type accept equipment in the United States subscribe to $(43 + (10 \log(TXpwr)) * (-1))$ or -13dBm IMD limit, it is lax compared to other nations as well a 3 GGP specifications. Amplifiers that we have tested designed to operate in the European market designed for TETRA and other services respond much better in the IMD arena than amplifiers **typically** marketed in

the United States. Below (Figure 4) is a two tone IMD sweep of a downlink amplifier that is FCC type accepted and marketed in the United States for use in Part 90 services.

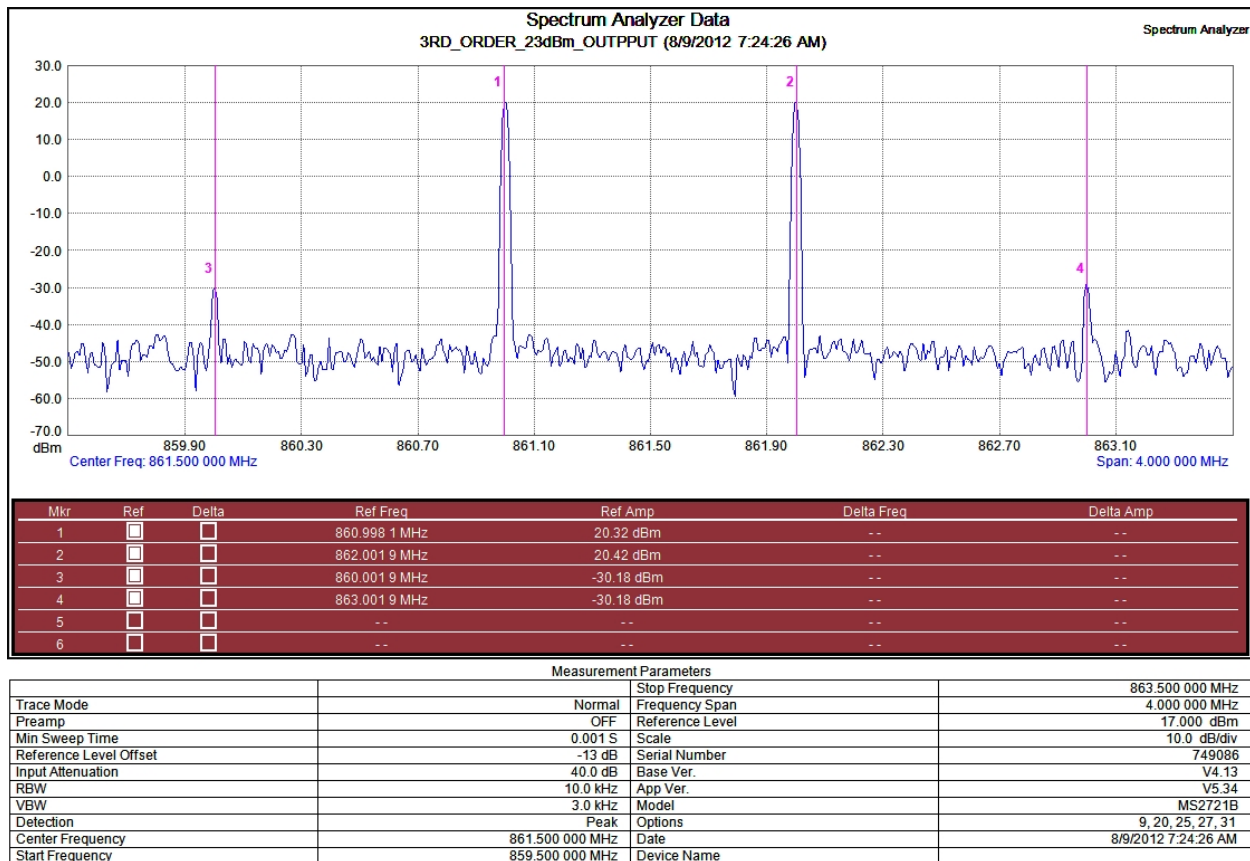


Figure 4

The amplifier above (figure 4) is rated for an output power level of 23 dBm. Note the third order products are running about -30 dBm.

Why is this important? As we see more of what we call non-engineered systems, it becomes very important. While we do not advocate the construction of non-engineered DAS systems, we often deal with the noise problems associated with them. This is becoming more common pace thus lower IMD levels will help alleviate this issue.

Other benefits to the lower IMD levels;

- a.) The downlink interference potential of these signals is reduced.
- b.) If the same IMD specification were applied to uplink amplifiers the potential for uplink interference is significantly reduced. For example, a signal booster generating an IMD at -13 dBm with no donor antenna gain can produce IMD interference out to 10 miles, the same signal booster with a -30 dBm IMD product will only produce interference for 1.4 miles (Based on -134 dBm noise floor 10 KHz channel and free space loss of 115 dB).
- c.) Using amplifiers that generate better IMD products require less L/C filtering for the reduction of out of band noise products.
- d.) As we develop more complex modulation formats and simply for passing LTE (Public Safety broadband) amplifiers will have to start reaching these linearity levels anyway.

6.) Should the Commission define the maximum unwanted noise that a signal booster generates, as it relates to part 90.210.

In reading part 90.210 it seems to pertain to emission masks and noise levels generated by a **transmitter**. As such, this has to do with the original generation of the carrier as well the amplification of the carrier signal and the mask which must be maintained. Since a BDA or DAS system simply amplifies an incoming signal, 90.210 does not apply. It is our opinion that an amplifier can in no way improve a signal that is already outside of the FCC defined emission mask. Thus any rules on signal boosters, BDAs or DAS amplifiers have to be tailored around the amplifiers ability to maintain the spectral purity of the **incoming signal**. Spectral purity is most related to the

linearity of the amplification system. Linearity can be tested in several ways. Some operators will test for error vector magnitude (EVM as will be used for CDMA,LTE) some use adjacent channel noise measurements (used for iDEN, GSM and Tetra) and some still use the old standby, two tone testing. Some manufacturers do all three. Each of these tests looks at different performance specifications of the amplifier. Our lab testing shows amplifiers that meet the EVM requirement for LTE (which will be coming soon to public safety) and amplifiers that meet adjacent channel noise requirements for iDEN run about a -30dBm two tone IMD level. Tri Power would suggest that the same specification be used on all amplification systems in order to alleviate the potential for market confusion.

7.) Other Comments

Amplifier Classification

TriPower questions the use of amplifier classifications of **Class A** and **B** type signal boosters. With the Commission moving to a 6.25 KHz channel spacing in the **Part 90** spectrum, today's **class A** signal booster will become tomorrow's **class B** signal booster. TriPower supports the use of good engineering practices to avoid the pitfalls of poorly designed systems. Most complaints leveled against so called **Class B** signal boosters are due to poor filter designs and the same problems exist in today's **DSP** based amplifiers. **Class A** signal boosters have the potential to cause harmful interference as well as **Class B**. In our experience most interference problems are caused by poor filtering at the output of high power amplifier (HPA) stage. Thermal noise and harmonic products that are created in the HPA are not being properly filtered thus creating noise outside of band of design. TriPower also questions the use of amplifiers (DAS or BDA) that have filter characteristics that have pass bands less than 150 KHz. When

filter pass-bands of less than 150 KHz are implemented detrimental time delays occur. Time Domain Interference (TDI) can be very harmful to the operation of any public safety system, much more so than amplifying adjacent channels with a broader filter. In most situations there is absolutely no harm in amplifying an adjacent channel and in fact may be preferable than dealing with TDI. TriPower contends that the time delay problem associated with narrow pass band, so called “**Class A**” amplifiers cause enough time domain problems that the operational bandwidth is widened to the point where the “**Class A**” amplifier actually passes more than one channel thus becomes a “**Class B**” amplifier. TriPower also contends that in order to combat the time domain issues, manufacturers claim to be “**Class A**” but in practice the skirts of the filters are so broad that what is called a 25 KHz filter is closer to a 100 KHz wide filter.

TriPower suggest that the Commission drop the **Class A** and **B** designators all together as they are **in practice**, irrelevant. If the Commission elects not to drop the **Class A and B** amplifier designation we ask that the Commission define the filter response curve that will constitute a **Class A** amplifier. Unfortunately, the Class designator has been used by some to **confuse** the market place.

Passive Intermodulation Interference (PIM)

One of the more alarming aspects of the Signal Booster industry is the creation of passive intermodulation (PIM). Like IMD products produced by active components, PIM products are produced in the passive components used to propagate the radio signals. Over the past few months TriPower has been involved in trouble shooting several DAS issues that are in fact caused by PIM rather than active component IMD. In the field we have been experiencing 3rd order PIM returns of -55 dBm due to poor installation practices as well as subpar passive component selection. When multiple systems operate in

the same building this can become a major issue. For instance DAS systems operating in the 851 to 867 MHz (SMR downlink) region combined with 868 to 896 MHz (Cellular downlink) region, produce 3rd order products from 806 to 849 MHz. (SMR and Cellular uplink). This is a very large problem as it can cut across so many services.

We now are seeing third order components as well as just thermal noise trash coming from 770 MHz public safety downlinks ending up hitting the C Block uplink band starting at 777 MHz.

While we all like to lay these problems at the feet of the equipment manufacturers, PIM products come from both the equipment manufacturers as well as poor installation practices. It has been our experience that very few systems are tested for PIM when they are commissioned.

TriPower believes that as these systems become more complex with carrier/public safety LTE, existing Part 90 and Part 22 services etc. combined together in a single building, that we must have qualified people engineering, installing and maintaining these systems. In large venues such as airports, stadiums etc. system reliability must be taken into account in for **all parties** not just those who are on a DAS but those that may be passively affected by a DAS. This would be especially true in the event of an emergency or natural disaster. We also believe that many of the issues that are brought to the Commission are due to a lack of knowledge in the industry. While TriPower fully understands that the Commission does not want to be in the business of certification, we would encourage the Commission to consider supporting a certification program for individuals engineering, installing and maintaining these systems. We would encourage the commission to support the Safer Buildings.org model or something like the old radio telephone licensing process. TriPower believes that having qualified

individuals installing these systems will take a heavy load off of the Commission and create more reliable systems for all parties involved.

TriPower would also ask the Commission to apply the same standards to “DAS” systems as they do to “Signal Boosters”. Both systems in effect do the same thing and some DAS system manufacturers use Signal Boosters as their primary distribution medium. However some of the so called “DAS” hardware manufacturers do not come close to the quality that signal booster manufactures are held to. This situation only serves to confuse the market place.

IV. Summary

While the Commission is looking to provide low cost alternatives for consumer grade signal boosters it appears that the Commission is correctly looking at the Signal Booster/DAS issue in a more macro sense. As the industry becomes more converged where by multiple carriers are placing systems within the same buildings it is important to look at the issue on a large scale basis. By implementing some of the ideas outlined above, the Commission can greatly enhance the user experience for all parties involved. Consumers will be able to purchase low cost alternatives for signal boosters and interference to carriers and public safety users will be greatly reduced.

Respectfully Submitted,

Gregory M. Glenn

Director of RF Engineering

TriPower Group

